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CONDITIONS OF TRANSFER OF TRAINING

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DEPARTMENT OF PSYCHOLOGY
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By
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CONDITIONS OF TRANSFER OF TRAINING

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INTRODUCTION

This study is an investigation of some of the conditions of transfer of training. We shall seek to answer these questions:

I. What is the relation of the following conditions of learning to transfer:

A. Learning to make a new response to an old stimulus?

B. Learning to make an old response to a new stimulus?

C. Learning to make a new response to a new stimulus?

II. What is the relation of the degree of integration of the initial learning to transfer in

A. Learning to make a new response to an old stimulus?

B. Learning to make an old response to a new stimulus?

III. What is the relation of certain similarities between the $S_1R_1S_2R_2$ terms of the initial and subsequent learning material to transfer in

A. Learning to make a new response to an old stimulus?

B. Learning to make an old response to a new stimulus?

In most of the previous studies of learning transfer, the stimulus-response terms are undifferentiated. The usual procedure is to learn task *A*, then task *B*, check and compare the two results, and ascribe the difference to transfer. As a consequence, results have been obtained which give positive, zero, and negative transfer. Since the previous experiments have not been made for the purpose of reconciling these diverse results, we are attempting such a reconciliation by discovering some of the conditions of transfer.

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[1] From the Psychological Laboratory of the University of Chicago. The writer wishes to acknowledge his indebtedness to Professors Edward S. Robinson and Arthur G. Bills for assistance in planning and completing the study.

All transfer studies may be classified on the basis of whether or not a differentiation is made between the stimulus and response terms of the experimental situation, and the extent to which these terms are subjected to variation. According to this classification, transfer studies may be grouped into three classes.

I

In the first class of studies, *the stimulus-response terms in the experimental situation are undifferentiated.*

The great mass of transfer studies belong to this class. Examples include the studies of Wiltbank, Webb, Ho, Poffenberger, Waters, Kline and Owens, Swift, Starch, James, Scripture Smith and Brown, Thorndike and Woodworth, Winch, Ebert and Neumann, Bogardus and Henke, Fraker, Bagley, Judd, Richardson, and many others.

II

In the second class of studies, *the stimulus-response terms in the experimental situation are differentiated, and the influence of one variable is examined.*

The studies of Hunter, Pearce, Wylie, Bair, and Kline belong to this class.

Hunter, using a T-shaped discrimination box, teaches rats to turn to the right when given a light and to the left when not given a light, then to the left when given the light and to the right when not given the light; the rats must thus learn to make a new response to an old stimulus. The results are given in average total number of trials required in learning per habit.

Habit I, 286
Habit II, 603
Negative transfer, 111 percent

Pearce obtains approximately the same results in an earlier study.

Kline teaches subjects to respond to given pieces of literature, such as the Scarlet Letter, with the name of some author other than the correct one; moreover the subjects are classified in respect to their familiarity with the several pieces of literature. In this manner, Kline obtains the relation between learning to make a new response to an old stimulus and the strength of the connection between the original response (correct author), and the given stimulus. Kline obtains negative transfer in every case, except when the initial learning is extremely imperfect.

Wylie teaches rats to make a negative response to light, sound, or pain, and then a negative response to a different one of the three stimuli; the rats must thus learn to make an old response to a new stimulus in an old environment. His results, arranged according to six different combinations, follow:

Light to sound, 244 percent positive transfer
Light to pain, 21 percent positive transfer
Sound to light, 33 percent positive transfer
Sound to pain, 54 percent positive transfer
Pain to light, 36 percent positive transfer
Pain to sound, 68 percent positive transfer

Bair, using a specially prepared typewriter, tests the ability of subjects to respond to two series of 55 colors (6 different colors) under two arrangements of a color keyboard. The three situations indicated below are provided. In passing from task 1 to 2, the subject makes an old type of response to a new list of stimuli; in passing from task 2 to 3, the subject makes a new type of response to an old list of stimuli; the former results in positive and the latter in negative transfer, thus lending support to the findings of Hunter, Pearce, Kline, and Wylie cited above. The results are given in repetitions required per task, at a constant rate of 104 strokes per minute.

1. Series *A*, arrangement *A*, 40 repetitions
2. Series *B*, arrangement *A*, 13 repetitions
3. Series *B*, arrangement *B*, 23 repetitions

III

In the third class of studies, *the stimulus-response terms in the experimental situation are differentiated, and the influence of two or more variables is examined.*

The present study belongs to this class. It is in fact the first and only study of its type which has as yet appeared. Previous authors have differentiated the stimulus-response terms. Previous authors have varied the degree of integration of the initial learning. But they have not examined the relation of similarity of certain ones of the $S_1R_1S_2R_2$ terms to learning transfer. Moreover, in no previous study has the combined influence of several kinds of variation been examined. We are therefore attempting to investigate in this study the relation and the interrelation of the following three variables to learning transfer:

Identity of certain ones of the $S_1R_1S_2R_2$ terms
Degree of integration of the initial learning
Similarity of certain ones of the $S_1R_1S_2R_2$ terms.

TECHNIQUE

(1) *Learning Terms Defined*

Learning transfer relates to the effect of initial upon subsequent learning. In this investigation, the initial and subsequent learning are further differentiated into stimulus and response terms, which are designated initial stimulus, initial response, subsequent stimulus, subsequent response, $S_1R_1S_2R_2$.

(2) *General Nature of the Learning Material*

The learning material in these studies consists of nonsense syllables. The syllables may be similar, different, or identical; by arbitrary definition, 'similar' syllables are syllables which vary only in respect to the final letter, such as var, vam.

(3) *Description of the Conditions, Relative to*

(*a*) *Identities between Certain of the* $S_1R_1S_2R_2$ *Terms*

The relation of identity of the $S_1R_1S_2R_2$ terms is varied. In condition IX, the terms are all different. In conditions I, II, III, IV, the S_1 and S_2 are identical, which means that the subjects are required to learn a new response to an old stimulus. In conditions V, VI, VII, VIII, the R_1 and R_2 are identical, which means that the subjects are required to learn to make an old response to a new stimulus.

(*b*) *Similarities between Certain of the* $S_1R_1S_2R_2$ *Terms*

In conditions I, V, IX, no similarities are present. In conditions II and VI, the initial stimulus and initial response are similar. In conditions III and VII, the subsequent stimulus and subsequent response are similar. In condition IV, the initial response and subsequent response are similar, and in condition VIII, the initial stimulus and the subsequent stimulus are similar.

(*c*) *Integration of the Initial Learning*

In each of the nine conditions, an initial list of syllables is presented to the subject either 0, 2, 6 or 12 times, regardless of the number of repetitions required to learn the initial list. By means of this variation, situations are provided in which the original material may be entirely unlearned, slightly learned, almost learned, completely learned, or overlearned. A subsequent list is then repeatedly presented until it is learned. It is assumed that a list is learned, when the subject can correctly anticipate the second member of each pair before it actually appears. The last repetition therefore is not counted. The following tables is a partial summary of the conditions.

SUMMARY OF CONDITIONS ILLUSTRATION OF IDENTITIES AND SIMILARITIES BETWEEN TERMS, IN THE DIFFERENT CONDITIONS

Condition	Initial learning		Subsequent learning		Relation of initial to subsequent material
	Stimulus S_1	Response R_1	Stimulus S_2	Response R_2	
I	req	kiv	req	zam	S_1S_2 identical
II	bij	bic	bij	tab	S_1S_2 identical, S_1R_1 similar
III	mir	ped	mir	miy	S_1S_2 identical, S_2R_2 similar
IV	tec	zox	tec	zop	S_1S_2 identical, R_1R_2 similar
V	lan	qip	fis	qip	R_1R_2 identical
VI	soj	soy	nel	soy	R_1R_2 identical, S_1R_1 similar
VII	zaf	qer	qec	qer	R_1R_2 identical, S_2R_2 similar
VIII	bes	yor	bef	yor	R_1R_2 identical, S_1S_2 similar
IX	xal	pom	cam	lup	all terms different

(4) *Rate of Presentation*

A 2-second interval is given per successive exposure.

(5) *Method of Presentation*

In all of the conditions, a variation of the paired-associates method is used, in which the subject is presented first with a given syllable, then with the syllable and its associate, and so forth. An illustrative list of syllables follows:

Initial S_1R_1 list (S_1 with R_1)		Subsequent S_2R_2 list (S_2 with R_2)	
req		fiz	
req	kiy	fiz	sej
taw		mip	
taw	rif	mip	boc
qix		bul	
qix	lep	bul	puw
wam		nic	
wam	bos	nic	git
zed		caj	
zed	dib	caj	lim

(6) *Length of the Lists*

It was necessary, in arranging the length of the lists for the various conditions, to make certain that they were long enough, in all cases, to require several repetitions in the learning. Conditions III and VII permitted more rapid learning than the other conditions, and hence longer lists were employed in these two conditions. Therefore, the length of the lists, as determined by pre-experimentation is 5 syllables in conditions I, II, IV, V, VI, VIII, IX, and 7 syllables in conditions III and VII.

(7) *Different Groupings of the Pairs of Syllables*.

The members of each pair of syllables remain invariably together, but the order of the pairs in the list is varied in an irregular manner from trial to trial. This arrangement, which provides for four different groupings of the pairs per list, follows:

Repetition of list	Sequence of presentation of the syllables per list				
1st	1	2	3	4	5
2d	4	1	5	3	2
3d	5	4	2	1	3
4th	2	5	1	3	4
5th, etc.	1	2	3	4	5

(8) *Practice Effects Equalized*

The conditions of integration are regularly shifted per subject per cycle in a manner calculated to equalize the benefits to be derived from practice. The sequence is so adjusted that every subject studies each of the four conditions of integration under each of the four successive learning periods of the cycle.

(9) *Differences in Difficulty of Lists Adjusted*

The syllable lists are given in a sequence per subject per condition calculated to equalize their difficulty in learning. The sequence is so adjusted that each syllable list is learned 2 or more times under each of the conditions of integration, and under each of the four successive learning periods of a cycle group.

(10) *The Subjects*

Eighty-one college students served as subjects; nine are used in each condition, and each one is tested individually. Each subject is tested under each of the four conditions of integration, and this is repeated for four cycles. Thus sixteen periods of experimentation are required of each person, and as far as possible, these periods of experimentation are given one at a time, at the rate of one per day.

(11) *Apparatus*

The apparatus used in this study consists of a metronome, some adding machine paper, and a 12x12 inch cardboard in the center of which are two parallel 4½ inch slits ⅝ inches apart.

The metronome is used to provide 2-second intervals.

The adding machine paper is used as a convenient medium for presenting typewritten lists of syllables. In order to present four different groupings of lists of pairs, and in order to provide at least double spacing between successive items, rolls of approximately 36 inches in length are used.

The 12 x 12 inch cardboard is used in lieu of a memory drum. The syllable roll, concealed beneath the cardboard except for the small portion exposed between the two parallel slits, is pulled forward by the experimenter at regular intervals of 2 seconds per exposure item.

RESULTS

I

Relation of the following types of learning to transfer:

A. Learning to make a new response to an old stimulus.

B. Learning to make an old response to a new stimulus.

C. Learning to make a new response to a new stimulus.

TABLE I[2]

RELATION TO TRANSFER, OF LEARNING TO MAKE A NEW RESPONSE TO AN OLD STIMULUS, AN OLD RESPONSE TO A NEW STIMULUS, A NEW RESPONSE TO A NEW STIMULUS

Condition	Mean repetitions required in the subsequent learning under conditions of 0 and 12 repetitions of initial learning		Mean values letting the condition 0 value = 100	
	0	12	0	12
I	10.3	11.2	100	109
V	14.4	9.0	100	63
IX	9.9	8.3	100	84

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[2] Each mean value in this and the following tables is an average of 36 measures.

The probable errors are omitted from the tables, chiefly for reasons of convenience. The P.E. of the difference of given means is stated in the discussion, in a few crucial instances; the subsequent findings hinge upon these values.

The great differences between the 0 integration values in this and the following tables, are not of any particular significance inasmuch as

a. different persons serve as subjects in each of the nine conditions of the study,

b. different lists of memory material are used in each of the nine conditions of the study,

c. longer lists of memory material are used under some of the conditions than under others,

d. learning is easier under some of the conditions than under others, since the pairs of syllables are similar in some conditions and different in others.

The data of Table I indicate that learning to make a new response to an old stimulus is not benefited by the initial learning of 12 repetitions; in fact the number of repetitions required increases from 10.3 to 11.2 indicating a negative transfer of 100 : 109, although the difference of 0.9 repetitions is statistically insignificant.

Learning to make an old response to a new stimulus is materially benefited by the initial learning; the number of repetitions required decreases from 14.4 to 9.0 indicating a positive transfer of 100 : 63. The difference of 5.4 repetitions is statistically significant since it is more than three times the P.E. of the difference, 1.5.

Learning to make a new response to a new stimulus is slightly benefited by the initial learning; the number of repetitions required decreases from 9.9 to 8.3 indicating a positive transfer of 100 : 84. The difference of 1.6 repetitions is too small to be of much significance since the P.E. of the difference is 1.5.

In general the data indicate that there is a marked positive transfer in learning to make an old response to a new stimulus (100 : 63), a slight positive transfer in learning to make a new response to a new stimulus (100 : 84), and a slight negative transfer in learning to make a new response to an old stimulus (100 : 109).

II

Relation of the degree of integration of the initial learning to transfer in

A. Learning to make a new response to an old stimulus.
B. Learning to make an old response to a new stimulus.

TABLE II

Influence of the Degree of Integration (0, 2, 6, 12 Repetitions) of the Initial Learning upon the Subsequent Learning. Relative to Learning to Make a New Response to an Old Stimulus, an Old Response to a New Stimulus, a New Response to a New Stimulus.

Condition	Mean repetitions required in the subsequent learning under conditions of 0, 2, 6, 12 repetitions of initial learning				Mean values letting the condition 0 value = 100			
	0	2	6	12	0	2	6	12
I	10.3	12.1	11.9	11.2	100	117	116	109
V	14.4	16.6	12.0	9.0	100	115	83	63
IX	9.9	9.9	10.7	8.3	100	100	108	84

In learning to make a new response to an old stimulus, the number of repetitions required varies with the degree of integration of the initial learning: 2 repetitions causes a negative transfer of 100 : 117; 6 repetitions causes a negative transfer of 100 : 116; and 12 repetitions causes a negative transfer of 100 : 109.

In learning to make an old response to a new stimulus, 2 repetitions of the initial learning causes a negative transfer of 100 : 115; 6 repetitions causes a positive transfer of 100 : 83; and 12 repetitions causes a positive transfer of 100 : 63.

In learning to make a new response to a new stimulus, 2 repetitions of the initial learning causes a zero transfer; 6 repetitions causes a negative transfer of 100 : 108; and 12 repetitions causes a positive transfer of 100 : 84.

The difficulty of the learning tends to decrease, as the amount of the initial learning is increased from 2 to 6 to 12 repetitions (compare 117 with 116 with 109; also 115 with 83 with 63; also 100 with 108 with 84); this is true moreover, regardless of whether or not similarities are present (see tables III and IV, and compare also 101,90,90; 127,123,102; 102,101,80; 103,81,77; 66,56,40; 84,64,44); the decreased difficulty may show itself in terms of a decreasing negative transfer (117,116,109), or in terms of a shift from negative to positive transfer (115,83,63), or in terms of an increasing positive transfer, if similarities are involved (see table IV, 84,64,44).

III

Relation of the similarity between the $S_1R_1S_2R_2$ terms of the initial and subsequent material, to transfer in

A. Learning to make a new response to an old stimulus.

B. Learning to make an old response to a new stimulus.

TABLE III

Influence of Similarity of Terms Involved in Initial and Subsequent Material upon the Subsequent Learning When Learning to Make a New Response to an Old Stimulus

Condition	Mean repetitions required in the subsequent learning under conditions of 0, 2, 6, 12 repetitions of initial learning				Mean values letting the condition 0 value = 100			
	0	2	6	12	0	2	6	12
I	10.3	12.1	11.9	11.2	100	117	116	109
II	11.1	11.2	10.0	10.0	100	101	90	90
III	8.2	10.4	10.1	8.4	100	127	123	102
IV	9.6	9.8	9.7	7.7	100	102	101	80

Learning to make a new response to an old stimulus when no similarities are present, is slightly hindered by 12 repetitions of initial learning, 100 : 109. If the stimulus and response terms of the subsequent learning are similar, transfer is practically zero, 100 : 102. If the stimulus and response terms of the initial learning are similar, a slight positive transfer occurs, 100 : 90. If the response terms of the initial and subsequent learning are similar, a further slight increment of positive transfer is added, 100 : 80. In general, the learning is least facilitated when no similarities are present (compare 109 with 90,102,80), and most facilitated when the initial and subsequent responses are related (compare 80 with 109,90,-102); the first gives a slight degree of negative transfer, the latter a moderate degree of positive transfer. The relative effectiveness of the four conditions of experimentation varies irregularly with the degree of integration of the initial learning. Under the best conditions, a slight positive transfer occurs; under the poorest conditions, a slight negative transfer occurs.

TABLE IV

INFLUENCE OF SIMILARITY OF TERMS INVOLVED IN INITIAL AND SUBSEQUENT MATERIAL UPON THE SUBSEQUENT LEARNING, WHEN LEARNING TO MAKE AN OLD RESPONSE TO A NEW STIMULUS

Condition	Mean repetitions required in the subsequent learning under conditions of 0, 2, 6, 12 repetitions of initial learning				Mean values letting the condition 0 value = 100			
	0	2	6	12	0	2	6	12
V	14.4	16.6	12.0	9.0	100	115	83	63
VI	12.8	13.2	10.4	9.8	100	103	81	77
VII	13.1	8.7	7.3	5.3	100	66	56	40
VIII	13.5	11.4	8.7	5.9	100	84	64	44

Learning to make an old response to a new stimulus when no similarities are present, is materially aided by an initial learning of 12 repetitions; the repetitions required decrease from 14.4 to 9.0, a positive transfer of 100 : 63. If the stimulus and response terms of the initial learning are similar, the amount of positive transfer slightly decreases, 100 : 77. If the stimulus and response terms of the subsequent learning are similar, the amount of positive transfer is greatly increased, 100 : 40; so also, if the initial stimulus and the subsequent stimulus are similar, 100 : 44. In general, the positive transfer is greatest when the subsequent stimulus is similar either to the subsequent response, 100 : 40 or to the initial stimulus, 100 : 44. The positive transfer is least when the similarities are restricted to the terms of the initial learning, 100 : 77; in this latter case, the similarity is even a disadvantage; compare 100 : 77 with 100 : 63.

IV

Summary of results, concerning the conditions of transfer of training:

(1) Learning to make an old response to a new stimulus almost invariably gives marked positive transfer, whereas learning to make a new response to an old stimulus usually results in a slight degree of negative transfer; this is true regardless of whether the

Integration is controlled and the similarity controlled
Integration is varied and the similarity controlled
Integration is controlled and the similarity varied[3]
Integration is varied and the similarity varied.[3]

(2) The difficulty of subsequent learning tends to decrease as the amount of the initial learning is increased from 2 to 6 to 12 repetitions, regardless of whether learning to make a new response to an old stimulus, or learning to make an old response to a new stimulus; this decrease may be in terms of a decreasing negative transfer, in terms of a shift from negative to positive transfer, or in terms of an increasing positive transfer.

(3) The effects of similarity vary as follows:

(*a*) When learning to make a new response to an old stimulus, the learning is least facilitated when no similarities are present, and most facilitated when the initial and subsequent response are similar; when least facilitated, a slight degree of negative transfer occurs, and when most facilitated, a moderate degree of positive transfer occurs.

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[3] Compare conditions I and V, II and VI, III and VII, IV and VIII respectively, of tables III and IV.

(*b*) When learning to make an old response to a new stimulus, the learning is most facilitated when the subsequent stimulus is similar either to the subsequent response or to the initial stimulus, and least facilitated when the similarities are restricted to the factors of the initial learning; in this latter case, the similarity is even a disadvantage. But in all cases, marked positive transfer occurs.

Interpretation

I

Our data (condition I) support the findings of both Hunter and Pearce; we find that learning to make a new response to an old stimulus is accompanied by a small degree of negative transfer, when no similarities are involved. Hunter and Pearce find a very marked negative transfer in training rats to turn to the right in a T-maze when given a light, to the left when not given the light, and then to the left when given the light and to the right when not given the light. The chief difference between the experiments, is that in the Hunter and Pearce studies the new and old responses are antagonistic muscular reactions, *i.e.*, the rats are taught first to turn to the right when given the light, and then later to turn to the left when given the light, etc., whereas in our condition I, the new and old responses (syllables) are different but not necessarily antagonistic reactions. This difference undoubtedly accounts in part for the greater negative transfer in the rat studies.

Our data (condition I) support in part the findings of Kline; in our study, learning to make a new response to an old stimulus invariably results in negative transfer, regardless of the degree of integration of the initial learning; the same is true of Kline's results, except when the integration of the initial learning is extremely imperfect (1 percent to 10 percent). In both studies, the greatest degree of integration of the initial learning, causes a negative transfer in the subsequent learning, but the amount of this negative transfer is less than that which results when the integration of the initial learning is somewhat less complete. Our data fail to support the findings of Kline in one respect: when the degree of the initial learning is meager, we usually obtain negative transfer, whereas Kline obtains a slight degree of positive transfer; this is in fact the only condition under which Kline obtains positive transfer.

Our data (condition V) support the findings of Wylie. In both studies, learning to make an old response to a new stimulus is accompanied by a marked degree of positive transfer, when the integration of the initial learning is complete. Wylie taught rats to make a negative response, first to either light, sound, or pain, and then to a different one of the three stimuli.

Our data support the findings of Bair. In both studies, learning to make an old response to a new stimulus gives positive transfer, when the integration of the initial learning is complete (condition V), whereas learning to make a new response to an old stimulus gives negative transfer (condition I).

Our data also support the findings of Ho, who studies the effect of varying degrees of integration of maze learning upon the learning of a second similar maze; he finds that an increasing degree of integration of the initial learning is accompanied by an increasing positive transfer. Wiltbank, in an earlier study of the same problem, when using the criterion of average time per trial, obtains about 75 percent positive transfer regardless of the degree of integration of the first maze learning; but when measured in average number of trials, or in average errors per trial, positive transfer is obtained only after 16 or more trials upon the first maze.

II

Thorndike's theory of transfer is one of the more ambitious attempts to explain transfer. Thorndike says:[4]

> "The problem, which is clearly one of psychological fact, may be best stated in psychological terms as follows: How far does the training of any mental function improve other mental functions? . . . The answer which I shall try to defend is that a change in one function alters another only insofar as the two functions have as factors identical elements. The change in the second function is in amount that due to the

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[4] Thorndike, E. L., Educational Psychology, Briefer Course, 268–269.

change in the elements common to it and the first. . . . By identical elements are meant mental processes which have the same cell action in the brain as their physical correlate. It is of course often not possible to tell just what features of two mental abilities are thus identical."

The Thorndike theory was put forward primarily to explain positive transfer, inasmuch as this kind of transfer was practically the only kind to be explained, at the time of the formulation of the theory. The theory attempts to explain experimental data such as the following:

Swift in a cross education study employs ball-tossing and obtains positive transfer.

Scripture, Smith, and Brown in a cross education study, measure the ability of subjects to insert a needle into a small aperture; a positive transfer of 25 percent is obtained.

Starch in a study of cross education, employs mirror tracing, and obtains a 90 percent positive transfer.

Winch finds a positive transfer in the memory ability of girls.

Fracker in a study of memory of the order of four tones, obtains positive transfer.

Thorndike and Woodworth testing the ability of subjects to estimate the areas of different shapes, before and after training in judging the area of rectangles, find positive transfer in most of the cases.

Thorndike and Woodworth find that training in marking out words with given letters, aids 10 percent to 35 percent in another list in which different letters are used.

Starch in a study of transfer in arithmetic, tests individuals in simple mathematical procedures, before and after training them in mental multiplication. He finds a positive transfer of 20 percent to 40 percent.

Judd's experiment with boys who throw at a target under water, gives positive transfer. The boys to whom refraction is explained, progress more rapidly than the uninstructed boys.

Webb, testing both rats and human beings, seeks to ascertain whether there is transfer in passing from the learning of one maze to that of another. Webb's results show the presence of positive transfer to a marked degree in all but one or two instances.

Wiltbank in a study of transfer, runs rats through a series of mazes. In general, his results give positive transfer from maze to maze.

Thorndike's theory also attempts to account for instances of zero transfer, for it implies that where there are no identical elements between the two functions, the change in the second function will be nil. The experiments of James, Bagley, Thorndike and Woodworth deserve mention at this point.

James, testing himself in poetry-memorizing, before and after memorizing passages from another type of poetry, finds that memory training does not aid; in fact James memorized passages a bit faster before rather than after the memory training.

Bagley teaches pupils to produce neat arithmetic papers, and finds that neatness fails to carry over to other subjects; the spelling and language papers fail to show even slight improvement in neatness.

Thorndike and Woodworth train subjects in estimating the length of lines of ½ to 1½ inches; although the subjects improve about 25 percent during the training, they fail to show any improvement in the estimation of lines of 6 to 12 inches as a result of the training.

The Thorndike theory is silent concerning instances of negative transfer such as are found in the experiments of Hunter, Pearce, and others.

Both Hunter and Pearce, using a T-maze, train rats first to turn to the right when given a light, to the left when not given the light, and then to the left when given the light, to the right when not given the light. Their results show conclusively that learning the first task greatly hinders the learning of the second task.

The silence of the Thorndike theory concerning negative transfer, appears to have given rise to the Poffenberger extension of the Thorndike theory. This 'Thorndike-Poffenberger' theory may be summed up in three general propositions:

I. Where there are no identical bonds between stimulus and response, the influence will be neither positive nor negative.

II. Where there are identical elements, there will be positive transfer.

III. Where bonds are broken in the formation of new groupings, there will be negative transfer.[5]

Poffenberger, studying the influence of improvement in one simple mental process upon other related processes, seeks to determine the influence of training in cases which vary from close similarity between the two successive tasks, to instances in which there is marked antagonism between the two successive tasks. His conclusions are stated in the above three propositions. Poffenberger trains four subjects during the course of nine days, in each of these four tests: color naming, opposites, number checking, and addition; before and after this training, the subjects together with a control group are tested in each of the following seven tests: 1 form naming test, 1 adjective-noun test, 2 number group checking tests, and 3 calculation tests.

If we assume with Poffenberger that "where bonds are broken in the formation of new groupings, there will be negative transfer," then evidently no bonds are broken in Wylie's study in which rats are taught to make an old response to a new stimulus, since he obtains positive transfer. The same may be said of our conditions VI, VII, VIII.

But evidently bonds are broken in Hunter's study in which rats are taught to make a new response to an old stimulus, since he obtains negative transfer. The same may be said of our condition I.

The Thorndike-Poffenberger theory is weak and unstable, since it offers little more than the dogmatic implication that bonds are broken if negative transfer is obtained, and not broken if positive transfer is obtained. The theory is not subject to experimental test, if we are to assume that negative transfer is a cue to broken bonds, and vice versa.

Moreover, no a priori assumption is justified that bonds are or are not broken under any conditions of transfer. In fact there is no proof that bonds are not broken in learning to make an old response to a new stimulus, under which conditions, positive transfer usually occurs.

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[5] Poffenberger, A. T., Influence of Improvement in One Simple Mental Process upon other Related Processes, *J. Educ. Psychol.*, 1915, **6**, 474.

The Thorndike-Poffenberger theory represents little more than a guess concerning the 'neurology' of transfer. It gives no basis for prediction in a given case whether positive or negative transfer will occur. But in our study, the results are formulated in a set of laws which have predictive value, since they state some of the main objective conditions under which positive and negative transfer may be expected to occur. The following section constitutes our set of laws.

III

Laws Concerning the Conditions of Transfer of Training

(1) Learning to make an old response to a new stimulus results in a marked degree of positive transfer.

(2) Learning to make a new response to a new stimulus results in a slight degree of positive transfer.

(3) Learning to make a new response to an old stimulus results in a slight degree of negative transfer.

(4) Introducing similarities between two or more of the $S_1R_1S_2R_2$ terms increases positive transfer, and decreases negative transfer.

(5) With increasing degrees of integration of the initial learning, there is an increase in the amount of positive transfer, and a decrease in the amount of negative transfer; where the amount of negative transfer is slight, it shifts to positive transfer.

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